State of California
The Resources Agency
Department of Water Resources

MATRIX OF LIFE HISTORY AND HABITAT REQUIREMENTS FOR FEATHER RIVER FISH SPECIES SP-F3.2 TASK 2

BROWN TROUT

Oroville Facilities Relicensing
FERC Project No. 2100

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ARNOLD SCHWARZENEGGER
Governor
State of California

MIKE CHRISMAN
Secretary for Resources
The Resources Agency

LESTER A. SNOW
Director
Department of Water Resources

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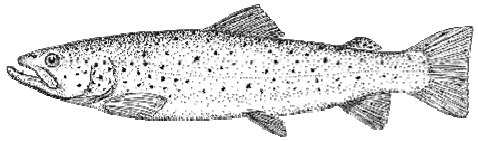
This report was prepared under the direction of

Terry J. Mills ..... Environmental Program Manager I, DWR

by

Paul Bratovich .....Principal/Fisheries Technical Lead, SWRI
David Olson..... Senior Environmental Scientist/Project Manager, SWRI
Adrian Pitts .....Associate Environmental Scientist/Author, SWRI
Meryka Atherstone .....Associate Environmental Planner/Author, SWRI
Allison Niggemyer .....Associate Environmental Scientist/ Author, SWRI
Amanda O'Connell ..... Environmental Planner/Author, SWRI
Karen Riggs ..... Environmental Planner/Author, SWRI
Brian Ellrott..... Environmental Scientist/Author, SWRI

Element	Element Descriptor	General	Feather River Specific
General			
common name (s)	English name (usually used by fishers and laypeople).	Brown trout	
scientific name (s)	Latin name (referenced in scientific publications).	The scientific name of brown trout is *Salmo trutta* (Moyle 2002).	
taxonomy (family)	Common name of the family to which they belong. Also indicate scientific family name.	Brown trout belong to the *Salmonidae* family (Moyle 2002).	
depiction	Illustration, drawing or photograph.		
range	Broad geographic distribution, specifying California distribution, as available.	Brown trout are native to Europe, North Africa, and Asia. Brown trout have been established in the USA, Canada, South America, Falklands, Africa, Australia, New Zealand, and Papua New Guinea (Moyle 2002).	
native or introduced	If introduced, indicate timing, location, and methods.	Brown trout were introduced to North America in 1883, and introduced into California in 1893 when embryos were brought in and successfully reared for planting in coastal streams (Moyle 2002).	
ESA listing status	Following the categories according to California Code of Regulations and the Federal Register, indicate whether: SE = State-listed Endangered; ST =State-listed Threatened; FE = Federally listed Endangered; FT = Federally-listed Threatened; SCE = State Candidate (Endangered); SCT = State candidate (Threatened); FPE = Federally proposed (Endangered); FPT = Federally proposed (Threatened); FPD = Federally proposed (Delisting); the date of listing; or N = not listed.	Brown trout are not a listed species in California (DFG 2002).	
species status	If native, whether: Extinct/extirpated; Threatened or Endangered; Special concern; Watch list; Stable or increasing. If introduced, whether: Extirpated (failed	Brown trout are reportedly widespread and abundant in California (Moyle 2002).	

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	introduction); highly localized; Localized; Widespread and stable; Widespread and expanding.		
economic or recreational value	Indicate whether target species sought for food or trophy. Whether desirable by recreational fishers, commercial fishers, or both.	Brown trout have a high recreational value. Brown trout are popular among anglers, reportedly because of their bottom feeding and piscivorous tendencies and their natural wariness (Moyle 2002).	
warmwater or coldwater	Warmwater if suitable temperature range is similar to basses; coldwater if suitable temperature range is similar to salmonids.	Brown trout are a coldwater fish (Moyle 2002).	
pelagic or littoral	Environment: Pelagic - living far from shore; Littoral - living near the shore.		
bottom or water column distribution	Environment: bottom (benthic) or along water column.	Adult brown trout are largely bottom-oriented pool dwellers in streams and rivers (Moyle 2002).	
lentic or lotic	Environment: Lentic - pertaining to stagnant water, or lake-like; Lotic - moving water, or river-like.	Young and small brown trout are reportedly found in riffles and pools. Reported optimal habitat conditions are medium to large, slightly alkaline, clear streams with swift riffles and large deep pools (Moyle 2002). Brown trout are reportedly very aggressive in both lotic and lentic environments (Nilsson 1963 *in* (Haraldstad and Jonsson 1983).	
Adults			
life span	Approximate maximum age obtained.	In the alpine lakes of Norway, the oldest recorded age of a brown trout is 38 years. In California, the oldest recorded age of a brown trout 9 years (Moyle 2002).	
adult length	Indicate: Length at which they first reproduce; average length and maximum length the fish can attain.	In California, brown trout reportedly reach lengths of 1.2–3.15 inches (3-8 cm) TL in the first year, typically averaging 2–2.8 inches (5-7 cm) TL. In the second year, brown trout reportedly reach lengths of 2.8–8.7 inches (7-22 cm) TL, typically averaging 5.1–6.3 inches (13-16 cm). In the third year, brown trout reportedly reach lengths of 5.1 –14.2 inches (13-36 cm) TL, typically averaging 7.5–11 inches (19-28 cm). In the fourth year brown trout reportedly reach lengths of 9.1–17.7 inches (23 –45 cm) TL, averaging 13.8–16.1 inches (35-41 cm) (Moyle 2002). Brown trout reportedly mature in 2-3 years, but some may wait	

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		7-8 years to spawn for (Moyle 2002). Brown trout reportedly mature at the end of the first year or as late as the eighth year, but most mature between the third and fifth year (Raleigh et al. 1986). Most male brown trout reportedly mature at age 4 and females at age 5, at lengths generally ranging from 12–19 inches (30.1–48.3 cm). However, some mature individuals were reported as small as 5 or 6 inches (12.7–15.2 cm) (Raleigh et al. 1986).	
adult weight	Indicate: Weight at which they first reproduce; average weight and maximum weight the fish can attain.	The largest known brown trout caught was a sea-run individual caught in Scotland measuring 40.6 inches (103 cm) TL and weighing 39.7 lbs (18 kg) (Moyle 2002). The largest brown trout recorded in California was reportedly caught in Upper Twin Lake and weighed 26.5 lbs (12 kg) (Moyle 2002).	
physical morphology	General shape of the fish: elongated, fusiform, laterally compressed, etc.		
coloration	Indicate color, and color changes, if any, during reproduction phase.	Brown trout have red and black spots on the body and adults are usually dark brown to olive brown dorsally, shading to yellow-brown on the sides, and white to yellow ventrally (Moyle 2002).	
other physical adult descriptors	Unique physical features for easy identification.	Brown trout is the only species of trout in California with both red and black spots on the body (Moyle 2002).	
adult food base	Indicate primary diet components.	Brown trout vary in their prey selection. Brown trout greater than 9.8 inches (>25 cm) TL reportedly feed on crayfish, terrestrial insects, dragonfly larvae, and their own young. At greater than 15.7 inches (>40 cm), brown trout reportedly feed exclusively on fish (Moyle 2002).	
adult feeding habits	Indicate whether plankton eater, algae eater, bottom feeder, piscivorous, active hunter, ambush predator, filter feeder. Night, day, dusk or dawn feeder.	Brown trout reportedly feed most intensely at dawn and dusk. They are also active hunters in the evening (Moyle 2002).	
adult in-ocean residence time	For anadromous species, age when they migrate to the ocean and duration spent in the ocean before returning to freshwater to spawn.		

Element	Element Descriptor	General	Feather River Specific
adult habitat characteristics in-ocean	For anadromous species, description of the ocean habitat utilized: whether along major current systems, gyres, pelagic (beyond continental shelves) and neritic (above continental shelves) zones, etc.		
Adult upstream migration (immigration)			
range of adult upstream migration timing	Time of year adults migrate upstream. If applicable, indicate for various runs.		
peak adult upstream migration timing	Time of year most adults migrate upstream. If applicable, indicate for various runs.		
adult upstream migration water temperature tolerance	Range of water temperatures allowing survival. Indicate stressful or lethal levels.		
adult upstream migration water temperature preference	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental.		
Adult holding (freshwater residence)			
water temperature tolerance for holding adults	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	Brown trout reportedly can survive water temperatures up to 82.4°F–94.2°F (28°C–29°C) for short periods of time, depending on the acclimation temperature. Adult brown trout reportedly prefer water temperatures ranging from 53.6ºF–68ºF (12ºC-20ºC). High growth rates reportedly occurred at water temperatures ranging from 53.6ºF–64.4ºF (12ºC–18ºC), and optimal growth is reported to occur at 62.6ºF–64.8ºF (17ºC–18ºC) (Moyle 2002). Brown trout reportedly can survive at temperatures of 32°F–80.6°F (0°C– 27°C) (Raleigh et al. 1986). The reported lethal water temperature for brown trout is 81°F (27.2°C) (Raleigh et al. 1986).	
water temperature preference for holding adults	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental.	Reported preferred water temperatures for brown trout are 53.6°F–68°F (12°C–20°C). If given a choice, brown trout will reportedly avoid water temperatures greater than 55.4°F (>13°C) (Moyle 2002).	

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		Reported preferred water temperatures for brown trout are 53.6°C–66.2°F (12°C–19°C) (Raleigh et al. 1986).	
water depth range for holding adults	Reported range of observed (minimum and maximum) water depth utilization.	Brown trout reportedly can be found at water depths of 2.3–11.5 feet (0.7–3.5 meters) (Moyle 2002). Brown trout were reportedly found at water depths of 0.2 to 5.5 feet (0.1–1.7 meters) (Raleigh et al. 1986).	
water depth preference for holding adults	Reported range of most frequently observed water depth utilization.	Adult brown trout reportedly preferred depths of 2.3–11.5 feet (0.7–3.5 meters) (Moyle 2002). Adult brown trout reportedly prefer resting and feeding at a water depth of 0.5 feet- (>15-cm) (Raleigh et al. 1986).	
substrate preference for holding adults	If bottom dwellers, indicate substrate: mud, sand, gravel, boulders, aquatic plant beds, etc. If gravel, indicate range or average size of gravel.	Adult brown trout reportedly prefer streams with riffles that have pea- to walnut-sized gravel (Moyle 2002). The optimal substrate for maintenance of a diverse invertebrate community, which brown trout feed on, is reported to consist of a mosaic of gravel, rubble, and boulders, with rubble dominating (Raleigh et al. 1986).	
water velocity range for holding adults	Reported range of observed (minimum and maximum) water velocity utilization.	Brown trout inhabit areas with variable water velocities (Moyle 2002). Adult brown trout reportedly utilize water velocities of 0–0.7 ft/sec (0–21.3 cm/sec) for resting, and 0.5–1.5 ft/sec (15.2–45.7 cm/sec) for feeding (Raleigh et al. 1986).	
water velocity preference for holding adults	Reported range of most frequently observed water velocity utilization.	Brown trout reportedly prefer relatively low velocities (Moyle 2002). The water velocity preferred for resting and feeding adult brown trout is reportedly less than 0.49 ft/sec (<15 cm/sec) (Raleigh et al. 1986).	
other habitat characteristics for holding adults	General description of habitat (e.g. turbid or clear waters, lentic or lotic, presence of aquatic plant beds, debris, cover, etc.).	Reported optimal riverine habitat is characterized by clear, cool to cold water; relatively silt-free rocky substrate in riffle-run areas; a 50-70% pool to 30-50% riffle-run habitat combination, with areas of slow, deep water; well-vegetated, stable stream banks; abundant instream cover; and, relatively stable annual flow and water temperatures. Brown trout also occupy the	

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		lower reaches of river systems in areas of low to moderate gradients (<1%) (Raleigh et al. 1986). Escape cover for adult and juvenile brown trout is provided by overhanging and submerged vegetation, undercut banks, instream objects such as debris piles, logs, and large rocks. Greater than 35% cover of the total stream area reportedly provides adequate cover for adult brown trout (Raleigh et al. 1986).	
timing range for adult holding	Time of year (earliest-latest) and duration of stay from upstream migration to spawning.		
timing peak for adult holding	Time of year when maximum number of adults are present before spawning.		
Spawning			
fecundity	Average or range in the number of eggs females lay in a spawning season.	Female brown trout reportedly can lay anywhere from 200 to 21,000 eggs, which is partially dependent on the size of the female. Female brown trout reportedly lay 77-103 eggs/inch (30-40 eggs/cm) of their FL (Moyle 2002).	
nest construction	Location and general description of nest -- substrates, aquatic plants, excavations, crevices, habitat types, etc.	The redd site is determined by the female brown trout, who turns on her side and begins to form a depression in the gravel by digging with her tail, which is known as cutting (Moyle 2002).	
nest size	Size and average dimensions of the nest.	Brown trout redds reportedly vary in length from 11.8–42.1 inches (30–107 cm) (Raleigh et al. 1986).	
spawning process	Indicate whether nest builder, broadcast spawner, or other.	Brown trout are nest builders (Moyle 2002). Brown trout generally move upstream in the fall to spawn or, in the case of lakes and reservoirs, into tributaries. Females build redds in the gravel and demersal eggs are deposited and covered with gravel. Nests are left unguarded. Brown trout usually spawn in running water (Raleigh et al. 1986).	
spawning substrate size/characteristics	Range of substrates used during spawning (e.g. mud, sand, gravel, boulders, beds of aquatic plants). Indicate presence of plant/wood debris, crevices at spawning sites. If gravel, indicate range of average size.	Brown trout have reportedly been observed using gravel 0.12-3.9 inches (0.3-10 cm) in diameter as a spawning substrate (Raleigh et al. 1986).	
preferred spawning substrate	Indicate preferred spawning substrate (e.g. mud, sand, gravel, boulders, plant bed, etc).	Brown trout reportedly prefer to spawn in gravel ranging from 0.39-2.8 inches (1-7 cm) in diameter (Raleigh et al. 1986).	

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water temperature tolerance for spawning	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	Brown trout reportedly have been observed spawning in water temperatures of 42.8ºF–55ºF (6ºC-12.8ºC) (Raleigh et al. 1986).	
water temperature preference for spawning	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.	Brown trout reportedly prefer to spawn in water temperatures within the range of 42.8ºF–50ºF (6ºC–10ºC) (Moyle 2002). Brown trout reportedly prefer to spawn in water temperatures within the range of 44.6ºF–48.2ºF (7ºC–9ºC) (Raleigh et al. 1986).	
water velocity range for spawning	Minimum and maximum speed of water current the spawning fish can tolerate.	Water velocity over brown trout redds in the Yellowstone River reportedly ranged from 1.58–2.5 ft/sec (48.2–75.9 cm/sec). In Oregon, water velocities near brown trout spawning sites reportedly ranged from 0.67–2.2 ft/sec (20.4–68.3 cm/sec) with an average of 1.5 ft/sec (44.5 cm/s). Oregon populations of brown trout were also reportedly observed spawning in water velocities of 0.45–1.5 ft/sec (13.7-45.7 cm/sec) (Raleigh et al. 1986).	
water velocity preference for spawning	Preferred water current (flow velocity) during spawning.	The reported optimal water velocity range for brown trout spawning was found to be 1.7–2.3 ft/sec (53.3–68.6 cm/sec). An average preferred velocity for brown trout spawning was reported as 1.3 ft/sec (39.4 cm/sec) (Raleigh et al. 1986). A habitat suitability index model suggests that the optimal water velocity for brown trout spawning is 1.3–2.3 ft/sec (40–70 cm/sec) (Raleigh et al. 1986).	
water depth range for spawning	Reported range of observed (minimum and maximum) water depth utilization.	Minimum brown trout spawning water depth reportedly ranges from 0.2–0.8 ft (0.06–0.2 m), while suitable water depth for spawning reportedly ranged from 0.4–3.0 ft (12.2–91.4 cm) (Raleigh et al. 1986).	
water depth preference for spawning	Reported range of most frequently observed water depth utilization.	Reported optimal water depth for brown trout spawning ranged from 0.8–1.5 ft (24.4-45.7 cm) (Raleigh et al. 1986).	
range for spawning timing	Earliest and latest time of season or year in which spawning occurs.	Brown trout spawning reportedly takes place in fall or winter (Moyle 2002). Brown trout spawning reportedly takes place from October through February, depending on the location (Raleigh et al. 1986).	

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peak spawning timing	Time of year most fish start to spawn.	In California, brown trout spawning reportedly takes place in November and December (Moyle 2002).	
spawning frequency (iteroparous/semelparous)	Semelparous - producing all offspring at one time, such as in most salmon. Usually these fish die after reproduction. Iteroparous - producing offspring in successive, e.g., annual or seasonal batches, as is the case in most fishes.	Brown trout are iteroparous (Moyle 2002).	
Incubation/Early development			
egg characteristics	Shape, size, color, in clusters or individuals, stickiness, and other physical attributes.		
water temperature tolerance for incubation	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	Water temperatures of 56ºF (13.3ºC) are reportedly lethal to brown trout eggs (Raleigh et al. 1986). The water temperature tolerance of brown trout eggs ranges from 32ºF–59ºF (0ºC–15ºC) (Raleigh et al. 1986).	
water temperature preference for incubation	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.	The optimal water temperature range for brown trout egg development, hatching success and fry emergence reportedly ranges from 44.6ºF–53.6ºF (7ºC–12ºC) and 43.9ºF–55.04ºF (6.6ºC–12.8ºC). For embryonic development, suitable water temperatures reportedly range from 41ºF–55.4ºF (5ºC–13ºC) (Raleigh et al. 1986).	
time required for incubation	Time duration from fertilization to hatching. Note: Indicate at which temperature range. Incubation time is temperature-dependent.	The time required for brown trout egg incubation reportedly ranges from 4–21 weeks depending upon water temperature, but typically lasts 7–8 weeks (Moyle 2002). Brown trout egg incubation reportedly lasts 148 days at 35.4ºF (1.9ºC) and 34 days at 52.1ºF (11.2ºC) (Raleigh et al. 1986). Brown trout egg incubation reportedly can require anywhere from 33 – 165 days, depending on the water temperature (Raleigh et al. 1986).	
size of newly hatched larvae	Average size of newly hatched larvae.		
time newly hatched larvae remain in gravel	Time of year of hatching, and duration between hatching and emergence from gravel.	The newly hatched brown trout larvae reportedly remain in the gravel 3-6 weeks before they emerge (Moyle 2002). Brown trout embryos overwinter in gravel, with fry emerging	

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		from the gravel in early spring. Dispersal of fry reportedly takes place immediately after emergence (Raleigh et al. 1986).	
other characteristics of larvae	Alevin -- early life history phase just after hatching (larva) when yolk-sac still present.	Brown trout fry prefer pools and rocky substrates, but often are excluded from these areas by older and larger juvenile trout, which also prefer these areas (Raleigh et al. 1986).	
timing range for emergence	Time of year (earliest-latest) hatchlings (larvae and alevins) leave or emerge from the nesting/hatching (gravel) sites.	Brown trout emergence reportedly occurs from December through April (Raleigh et al. 1986).	
timing peak for emergence	Time of year most hatchlings emerge.	Brown trout embryos overwinter in gravel, with fry emerging from the gravel in early spring (Raleigh et al. 1986).	
size at emergence from gravel	Average size of hatchlings at time of emergence.		
Juvenile rearing			
general rearing habitat and strategies	General description of freshwater environment and rearing behavior.	Juvenile brown trout reportedly stay at the tails of pools where the water is deeper, currents are less turbulent, and cover is close by. Fry reportedly live in quiet water close to shore among large rocks or under overhanging plants. (Moyle 2002). A social hierarchy reportedly is formed where dominant brown trout fry generally assume the energetically most profitable stream positions (Fausch 1984 *in* (Titus and Mosegaard 1991).	
water temperature tolerance for juvenile rearing	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	Juvenile brown trout reportedly can survive water temperatures ranging from 32ºF–80.6ºF (0ºC–27ºC) (Raleigh et al. 1986). The lower limit of water temperature for growth of juveniles is reported as 43ºF (6.1ºC) and the maximum water temperature tolerated is reported as 81ºF (27.2ºC) (Raleigh et al. 1986). The mean upper short term lethal water temperatures for stream-resident brown trout juveniles was reported as 29ºC (Raleigh et al. 1986).	
water temperature preference for juvenile rearing	Range of suitable, preferred, or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.	Adequate growth for brown trout reportedly occurred at water temperatures ranging from 44.6ºF–66.2ºF (7°C–19ºC), with optimal growth reportedly occurring at 53.6ºC (12ºC) (Raleigh et al. 1986). Water temperatures ranging from 44.6°F-66.2°F (7ºC–19ºC) is reported as the assumed water temperature optima for juvenile	

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		brown trout (Raleigh et al. 1986). Juvenile brown trout reportedly showed a preference for 17.6ºC in a laboratory experiments (Raleigh et al. 1986).	
water velocity ranges for rearing juveniles	Reported range of observed (minimum and maximum) water velocity utilization.	Brown trout fry reportedly prefer slow water velocities, while juvenile brown trout reportedly select waters with higher velocities, ranging from 0.33–0.13 ft/sec (10.1– 4 cm/sec) (Moyle 2002).	
water velocities preferred by rearing juveniles	Reported range of most frequently observed water velocity utilization.	Both fry and fingerling brown trout prefer velocities of less than 0.49 ft/sec (15 cm/s) (Raleigh et al. 1986).	
water depth range for juvenile rearing	Reported range of observed (minimum and maximum) water depth utilization.	Juvenile brown trout reportedly occur at shallower water depths than adults. As growth progresses, water depths of greater than 6 inches (15 cm) are reportedly preferred (Raleigh et al. 1986).	
water depth preference for juvenile rearing	Reported range of most frequently observed water depth utilization.	Brown trout fry reportedly choose edge water less than 11.8 inches (30 cm) in depth, while juvenile or yearling brown trout reportedly select deeper water ranging from 20-30 inches (50-75 cm) in depth (Moyle 2002).	
cover preferences for rearing juveniles	Type of cover for protection from predators used by rearing juveniles (e.g. crevices, submerged aquatic vegetation, overhanging vegetation, substrate cover, undercover bank, small woody debris, large woody debris).	Juvenile brown trout reportedly prefer cover consisting of large rocks, logs, and overhead cover. Larger individuals (greater than 9.8 inches or 25 cm in TL) remain under cover (e.g., undercut banks, logs) during the day (Moyle 2002).	
food base of juveniles	Indicate primary diet components. Also indicate the diet changes, if any, as growth occurs.	The food base of juvenile brown trout is mainly drift organisms, especially terrestrial insects. As they grow larger, brown trout juveniles spend more time selectively picking benthic invertebrates from the bottom of the stream. Once they exceed 9.8 inches (25 cm) TL, brown trout actively pursue large prey such as fish (including their own young), crayfish, and dragonfly larvae (Moyle 2002).	
feeding habits of rearing juveniles	Indicate whether plankton eater, algae eater, bottom feeder, piscivorous, active hunter, ambush predator, filter feeder. Night, day, dusk or dawn feeder. Also indicate change of feeding habits growth occurs.	Brown trout remain under cover during the day and come out to pursue prey at night (Moyle 2002).	
predation of juveniles	Indicate which species prey on juveniles.		

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timing range for juvenile rearing	Range of time of year (months) during which rearing occurs.	Juvenile brown trout rear in rivers year-round (Raleigh et al. 1986).	
timing peak for juvenile rearing	Time of year (months) during which most rearing occurs.	Juvenile brown trout rear in rivers year-round (Raleigh et al. 1986).	
Juvenile emigration			
time spent in fresh water prior to emigrating	Duration (in years and/or months) from emergence to emigration to the ocean.		
water temperature tolerances during emigration	Range of water temperatures allowing survival. Indicate stressful or lethal levels.		
water temperature preferences during emigration	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.		
emigration timing range	Time of year juveniles commence emigration and duration of emigration.		
emigration timing peak	Time of year most juveniles are emigrating.		
size range of juveniles during emigration	Minimum and maximum sizes (inches or mm) of emigrating juveniles. Indicate average size.		
factors associated with emigration	Pulse flows, water temperature changes, turbidity levels, photoperiod, etc.		
Other potential factors			
DO	Levels of dissolved oxygen in water expressed in mg/L tolerated by fish.	Optimal dissolved oxygen levels for adult brown trout appear to be greater than 12 mg/L at water temperatures greater than 50ºF (10ºC). Adult brown trout avoid water with dissolved oxygen concentrations of less than 5 mg/L (Raleigh et al. 1986). The incipient lethal level of dissolved oxygen for adult and juvenile brown trout is approximately 3 mg/l or less, depending on environmental conditions such as water temperature. (Raleigh et al. 1986). A minimal to optimal dissolved oxygen concentration for brown trout reportedly ranges from 3 to 27 mg/L at water	

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		temperatures less than 59˚F (15˚C) and a minimal to optimal dissolved oxygen concentration reportedly ranges from 5 to 29 mg/L at water temperatures greater than 59˚F (15˚C). Deaths of juveniles reportedly occurred at dissolved oxygen concentrations of 1.6 to 2.8 mg/L with water temperatures ranging from 48.2˚F to 69.8˚F (9 to 21˚C). Half of the juveniles were dead at oxygen concentrations of 1.5 to 2.5 mg/L, and all of the juveniles were dead at 1.3 to 2.3 mg/L dissolved oxygen. Mean lethal dissolved oxygen levels reportedly ranged from 1.42 mg/L at 48.9˚F (9.4˚C) to 2.53 mg/L at 68.9˚F (20.5˚C) (Raleigh et al. 1986).	
pH	Alkalinity/acidity of water (expressed in pH) that fish can tolerate.	Juvenile and adult brown trout reportedly tolerate a pH ranging from 5.0–9.5, but optimal growth reportedly occurs at a pH ranging from 6.8–7.8 (Raleigh et al. 1986).	
turbidity	Indicate turbidity or state of water (e.g., clear water or presence of siltation or organic/inorganic matter in water) that fish can tolerate.	Small young brown trout are found in riffles and pools; however, the optimum habitat for the brown trout reportedly is medium to large clear streams with swift riffles and large, deep pools (Moyle 2002).	
factors contributing to mortality	e.g., fishing/angling mortality, drastic habitat alterations, unfavorable climatic changes, etc.	The embryonic and alevin stages are critical for brown trout populations in CA because high winter flows can scour the developing fish out of the gravel, resulting in small or absent year classes (Moyle 2002).	

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